

AMENDMENTS TO THE SPECIFICATION

Please add the following new paragraph after the title ending of on page 1, line 1:

This application claims the benefit of US Provisional Application No. 60/529984, filed 12-16-2003, the disclosure of which is fully incorporated herein by reference.

Please add the following line to the end of the section entitled "Description of Related Art" at page 3, line 2:

FR 2 762 942 discloses a passive mixer with a differential input and a differential output. The passive mixer comprises field-effect transistors.

Please replace the section entitled "Summary of the Invention" beginning at page 3, line 4 and ending at page 6, line 18, with the following rewritten paragraphs:

Summary of the Invention

It is an object of the present invention to provide a quadrature mixer arrangement comprising two mixers for converting a signal having a first frequency to a signal having a second frequency. More specifically, it is an object of the invention to provide a mixer arrangement comprising two quadrature mixers, which are isolated from each other without substantially effecting the noise performance of the arrangement. Moreover, it is an object of the invention to provide a mixer arrangement that is suitable for implementation using MOS technology.

According to a first aspect of the invention, the above objects are achieved by a quadrature mixer arrangement for converting a first signal at a first frequency to a second signal at a second frequency.

The arrangement comprises a first mixer operatively coupled to a first and a second terminal. The first terminal is a positive radio-frequency (RF) terminal and the second terminal is a negative RF terminal. The arrangement further comprises a second mixer coupled in parallel with the first mixer and operatively coupled to the first, and second terminals. The first mixer is arranged to be conductive for a first and/or a second

state of a first mixing signal, and arranged to mix the first signal with the first mixing signal to provide the second signal. The second mixer is arranged to be conductive for a first and/or a second state of a second mixing signal, and arranged to mix the first signal with the second mixing signal to provide the second signal. A set of switch devices is provided in the signal path(s) between the mixers and the first and second terminals. Switch devices coupled to the first mixer are arranged to be conductive for the first and/or second state of the second mixing signal. Switch devices coupled to the second mixer are arranged to be conductive for the first and/or the second state of the first mixing signal.

The first and second mixing signals and their respective inverse signals are provided by four local oscillator (LO) signals, which are phase shifted $\pi/2$ radians in relation to each other.

The first and second mixers may comprise a set of mixing means, each having a first, second, and third terminal. The first mixer is adapted to be driven by a first LO signal and its inverse signal having a first and a third phase, respectively, received at the third terminals of the mixing means of the first mixer. The second mixer is adapted to be driven by a second LO signal and its inverse signal having a second and a fourth phase, respectively, received at the third terminals of the mixing means of the second mixer.

In each mixer, first and second switch devices may be provided in the signal path between the first terminals of the first and the third mixing means and the first RF terminal. Similarly, third and fourth switch devices may be provided between the second terminals of the second and fourth mixing means and the second RF terminal. Thus any short circuit between the IF terminals may be avoided.

The mixers and/or the switch devices may comprise FET transistors provided in CMOS technology.

The mixer arrangement may be provided either as a transmitter or receiver mixer. In a transmitter mixer, a quadrature IF signal will be provided as input signal and an RF signal as output signal. In a receiver mixer, an RF signal will be provided as input signal, and a quadrature IF signal will be provided as output signal.

According to a second aspect of the invention, a wireless communication device having a communication interface for wirelessly communicating with a remote communication device, comprising the mixer arrangement according to the invention achieves the objects of the invention.

The device may be a portable radio communication equipment, a mobile radio terminal, a mobile telephone, a pager, a communicator, an electronic organizer, or a smartphone.

According to a third aspect of the invention, a method of mixing signals for converting a first signal at a first frequency to a second signal at a second frequency achieves the objects of the invention.

The method comprises the step of receiving the first signal. The method further comprises the step of mixing the first signal in a mixer arrangement comprising a first and a second mixer coupled in parallel to provide the second signal. Each mixer is coupled to a first and a second terminal. The first terminal is a positive RF terminal and the second terminal is a negative RF terminal. The first mixer is controlled to be conductive for a first and/or a second state of a first mixing signal for mixing the first signal with the first mixing signal to provide the second signal. The second mixer is controlled to be conductive for a first and/or a second state of a second mixing signal for mixing the first signal with the second mixing signal to provide the second signal. The method further comprises the step of controlling a set of switch devices provided in a signal path between the mixers and the first and second terminals to operatively couple either the first or the second mixer to the first and second terminals. Switch devices coupled to the first mixer are controlled to be conductive for the first and/or the second state of the second mixing signal. Switch devices coupled to the second mixer are controlled to be conductive for the first and/or the second state of the first mixing signal.

Further embodiments of the invention are defined in the dependent claims.

It is an advantage of the invention that the IF short circuit paths between the parallel coupled mixers of the invention are eliminated. Furthermore, it is an advantage that the noise performance compared with the known art is substantially improved such that the mixer arrangement is well suited for implementation in MOS technology and may be adapted for low supply voltage and low (or zero) IF frequency.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.